PATENT SPECIFICATION

811,237

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COMPLETE SPECIFICATION

Check Valve for Oil Pipe Lines

We, PEACOCK BROTHERS LIMITED, a company organised and existing under the laws of Canada, of Box 1040, Montreal, Quebec, Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a check valve adapted for use in oil pipe lines.

The phenomenon of valve slamming brought about by the closing of the valve member upon the valve seat of a check valve under the force of a pressure wave passing through a long line to a terminal point at which the valve is located, gives rise to a reflected pressure wave. The function of a pipe line check valve is to prevent flow reversal. A delayed closing of the valve against reverse flow allows the returning column of fluid to gain momentum before the valve is completely closed; this momentum is expended in producing a shock wave resulting in noisy slamming of the valve, tending to shock and strain the seating surfaces of the valve seat and valve member. Prior attempts to dampen the valve member in its closing action have permitted substantial reverse flow leakage, detracting from positive action of the valve. Prior constructions of check valve for pipe line use are characterized by a closing of the valve after the fluid pressure has been reduced to zero. Weights may be utilized to assist in the firm closing of the valve but do not reduce the natural period of oscillation of the moving components.

It is a main object of the invention to provide a check valve construction particularly adapted for use in oil pipe lines and in which the natural period of oscillation of the moving components may be reduced to permit a quick closing of the valve before rather than after the pressure therein drops to zero.

It is another object of the invention to provide an improved form of check valve construction in which the valve member is positively brought to seating engagement with the seat of the valve under the force of valve member biasing means of such character that the closure force on the valve member increases as the valve member approaches seating engagement with the valve seat and the valve member moves quickly to closure before the pressure drops to zero.

It is a further object of the invention to provide an improved check valve construction particularly adapted for use in oil pipe lines and the like in which the valve seat is disposed between inlet and outlet ports in co-axial alignment therewith and wherein the inlet and outlet ports are of the same diameter and the valve seat is of a transverse sectional area and contour not less than that of said ports and wherein said valve member in the fully open position is disposed in a position of free clearance providing effectively a through-bore for said valve corresponding to the full diameter of said ports.

It is a still further object of the invention to provide a check valve construction having a through bore closeable by a valve member swingable through a small angle between the fully closed position and the fully open position at which it is disposed clear of the bore.

With these and other objects in view, the invention generally concerns the improvements in a check valve having a valve body with a through-bore defining co-axially aligned inlet and outlet openings of: valve structure comprising: a valve seat member located in said bore between the inlet and outlet openings thereof and having seating surfaces defining a valve seat thereon inclined at an angle of the order of fifty degrees with respect to the axis of said bore; a valve member engageable with said valve seat to occlude reverse flow of fluid through said bore; a swingable valve supporting arm; means connecting one end of said arm to said valve member; fulcrum means supporting said arm for swinging motion of said valve member from a fully closed position of seating engagement with said valve seat to a fully open position beyond said bore; and means including a spring, bias-

ing said arm with increasing force toward the closed position as said valve member moves toward said valve seat for seating engagement therewith.

Other objects of the invention will be appreciated by a study of the following description taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a plan view of a preferred form of a valve according to the invention with a part of the bonnet cover removed to partially reveal critical components of construction;

Figure 2 is a sectional view on the line 2—2 of Figure 1;

Figure 3 is a plan view of a modified form of valve construction according to the invention embodying a bow spring biasing means for the valve member, showing the cover of the valve bonnet removed;

Figure 4 is a sectional view on the line 4—4 of Figure 3;

Figure 5 is a plan view of a further modified form of valve construction according to the invention;

Figure 6 is a sectional view on the line 6—6 of Figure 5;

Figure 7 is a sectional view on the line 7—7 of Figure 6;

Figure 8 is a plan view of a further modified form of check valve of the invention;

Figure 9 is a sectional view of the valve of Figure 8 on the line 9—9 thereof; and

Figure 10 is a reproduction of a pressure curve showing the opening and closing of a valve of the invention wherein the time base of the curve has been collapsed to show only the critical portions thereof.

Referring to the drawings, the preferred form of valve construction of this invention is shown in Figures 1 and 2 and comprises a through-bore form of valve body 10 having axially aligned inlet and outlet openings or ports 11 and 12 having associated clamping flanges 13 and 14 respectively. An inner flange 15 of inwardly directed annular form is located adjacent the inlet opening 11 and supports a tubular valve seat member 16 fastened thereto by studs 17 and sealed with the sealing ring 18. As shown, the diameters D_i of the inlet opening 11, D_f of the flange 15, D_r of the valve seat member 16 and D_o of the outlet opening 12, are the same and are arranged co-axially with respect to the longitudinal axis 19. Generally, D_f, D_r should not be less than D_i D_o. An inclined valve seat is defined on the valve seat tube 16 by the valve seat surface 20 adapted to be engaged by the flange ring seating surface 21 of valve member 22.

A mounting bracket 23 fastened by bolts 24 to the valve seat member 16 has inwardly projecting spaced apart arms 25 supporting the hinge pin 26 pivotally supporting the valve supporting bias arm 27 adapted to act about the fulcrum means or pin 26 as a first order lever. The end 28 of arm 27 is pivotally connected by means of a pin 29 to the spaced apart bracket portions 30 forming an integral part of the valve member 22. The accurate seating of the valve member 22 on the inclined valve seat 20 is capable of adjustment by the seating screw 31 mounted in the arm 27 and threaded into the valve member 22 as at 32. The other end of the bias arm 27 is defined by spring connecting means in the form of the spaced apart arm portions 33 having pivot support means 34 thereon adapted to mount the moving ends 35 of the spaced apart tension coil springs 36 at a point on said arm beyond the fulcrum means 26 remote from the end 28 thereof. The other anchored ends 37 of the springs extend about anchorage pins 38 in anchorage bracket 39 fastened by bolts 40 to abutments 41 formed in a bonnet portion 42 of the valve body or casing 10.

The bonnet portion of the valve body or casing rises outwardly preferably at right angles to the longitudinal axis 19 of the valve and is of an inner diameter in the region of the bonnet opening 43 thereof, permitting free passage of the valve seat member and valve member assembly associated therewith through the bonnet opening for servicing. A suitable cover 44 is fastened to the bonnet 42 by means of studs 45 to provide an effective sealing of the bonnet by means of a suitable sealing ring 46 or other gasket means.

Preferably, the cover 44 embodies a downwardly projecting stop member 47 adapted to engage the spaced apart bracket portions 30 of the valve member to limit the upward motion of the latter to a predetermined fully open position at which the valve member is disposed as at 48 free of the through-bore of the valve body.

It will be observed that upon opening of the valve shown in Figures 1 and 2, the valve springs are extended to increase the effective tensioning thereof while the spring angle defined by the angle between a line joining the points 34 and 38 and a line joining the pivot 26 and the point 38, decreases as the valve opens but never becomes negative; that is, while the biasing force applied to the valve member decreases as the valve member is raised to the fully open position, the spring never moves effectively over-center with respect to the fulcrum means 26 and therefore the valve member even in the fully open position is under a resultant spring pressure or biasing force which is relatively small but nevertheless positive. Accordingly, flow may continue through the valve at relatively low pressure sufficient to maintain the valve member in the fully open position. By this means, the pressure drop through the valve may be at a minimum when operating at full bore; that is, when flow through the pipe line is at its maximum and pressure drops along the

line are high. The pressure drop experienced with check valves of the prior art is not therefore materially increased by the adoption of improvements of the invention and yet the valve mechanism of the invention applies an increasing closing force or biasing force on the valve member as the forward flow decreases until the valve member is closed at a point before the pressure reaches zero, as will be brought out in more detail hereinafter.

The specific structure of valve adapted to function in accordance with the invention is subject to modification to a more elementary form as is illustrated in the modification of Figures 3 and 4. In this other form of the invention, the valve body 49 has axially aligned inlet and outlet openings 50 and 51 as before between which are located a tubular valve seat member 52 of no lesser diameter and supported by studs 53 on the inner flange 54. The valve member 55 adapted to seat on the inclined valve seat 56 is pivotally supported as at 57 on the bias arm 58 hinged on spaced apart arms 59 on the hinge pin 60 supported in mounting bracket 61 bolted as at 62 to the valve seat member 52. Bracket 61 embodies a stationary anchorage member 63 having an anchorage recess 64 serving as an abutment for one end 65 of the compression bow spring 6 engageable by its other end 67 in the retaining lip portion 68 of the bias arm 58.

The angle between a line joining the points of action of the ends of the biasing spring and a line joining the pivotal axis 60 of the valve member and the outward end 67 of the spring member, decreases as the valve member opens but remains slightly positive even when the valve member is in the fully open position as indicated by the lines 69. As before, means are provided for limiting and defining the fully open position of the valve and comprise the downward projections 70 from the cover 71 of the bonnet 72 adapted to be engaged by the projecting portions 73 of the valve member. By reason of the decreasing spring angle as the valve member is moved toward the open position, the resulting biasing force on the valve member likewise decreases through the compression force exerted by the spring may increase. As before, means are provided for aligning the valve member for accurate seating with the valve seat 56 and comprise the adjustable seating screw 74 extending from the bias arm 58 for threaded engagement as at 75 in the valve member.

It will be observed that the bonnet 72 in its interior contours provides a cavity 73a adapted for free acceptance of the valve member structure including the actuating mechanism therefor whereby the valve member may be disposed in the fully open position fully clear of the effective through-bore of the valve body.

A yet further modification of construction of check valve of the invention is illustrated in Figure 6 wherein a cantilever leaf spring is utilized in an arrangement providing a decrease in the effective spring angle upon opening of the valve member, as shown in Figures 5 to 7. The valve body 76 has inlet and outlet openings 77 and 78 in axial alignment and of the same diameter having a tubular valve seat member 79 seated in a socket 80 of the body by means of an annular screw ring 81. The bonnet 82 having an enlarged opening 83 supports an anchorage platform 84 fastened to the inwardly directed supporting protuberances 85 by means of bolts 86. Abutment 87 on platform 84 carries a leaf spring 88 clamped thereto by bolts 89 and clamping bar 90. The spring 88 extends across the enlarged bonnet cavity 91 in cantilever manner for engagement of its free end 92 with roller 93 mounted on axle 94 supported by the bias arm 95 pivoted as at 96 at one end thereof to the downwardly extending bracket portion 97 of the platform 84. The other end of the bias arm 95 pivotally supports the valve member 98 and embodies a valve member aligning screw 99 for accurate seating of the valve member with the inclined valve seat 100. In this case, the spring angle may be defined as the angle between a line joining the points of action of the pivots 96 and 93 and a line joining the latter points when disposed at right angles to the free end 92 of the cantilever leaf spring 88.

Aside from the differences in spring construction, there are two main points of additional interest in the form of check valve shown in Figures 5 to 7. Thus it will be observed that the valve member and its mounting components are removable with the anchorage platform 84 as a complete assembly whereby servicing of the valve by removal of the critical components through the bonnet opening 83 is greatly facilitated. It is also to be observed that the valve member 98 in the form shown in this modification embodies an inwardly directed piston element 101 fastened to the inner face 102 of the valve member by means of screws 103 and of a contour providing slight clearance 104 with the inner bore surface 105 of the valve seat tube 79 in the region of the valve seat 100. Accordingly, small pressure pulsations which would otherwise cause chattering of the valve member, effect slight movement thereof which does not contribute to material flow by reason of the obstruction of the piston element 101. Thus, chattering of the clapper plate or valve member 98 is substantially obviated and the necessity of maintaining the valve member in firm engagement with the valve seat under the action of a heavy biasing force does not become essential. Therefore, the biasing force required and the spring pressure necessary to accomplish same may be selected,

having regard substantially only to the rate at which valve closure is desired, having regard to pressure conditions in the valve rather than having regard also to the force necessary to maintain the valve fully closed under conditions of pressure fluctuation.

A still further modified form of check valve construction of the invention is shown in Figures 8 and 9 and comprises a valve case or body 106 having a through bore 107 extending from the inlet opening 108 to the outlet opening 109. The tubular valve seat member 110 is in the form of an elliptical ring-like structure seating in an inclined recess 111 of the valve body. The bore 112 of the valve seat member 110 conforms to the bore 107.

The valve 106 has a bonnet structure 113 formed thereon in which the enlarged opening 114 permits the removal therethrough of valve mechanism 115 when the cover 116 normally held onto the bonnet by bolts 117 has been removed. A removable bell shaped clamping member 118 seats upon the valve seat member 110 to clamp the latter into the recess 111 of the valve body. The bell shaped clamping member embodies projecting fittings 119 carrying fulcrum means in the form of a pivot pin 120 pivotally supporting valve biasing lever arm 121 which rigidly carries valve member 122 by means of the bolt connecting assembly 123.

A pair of opposed lever arms 124 disposed in spaced apart relation along the axis of pin 120 and forming a part of the lever arm 121 are connected to one end of the parallel spaced apart tension springs 125, the other ends of which are connected to spaced apart recesses (not shown) in the transverse anchorage pin 126 of the bell shaped clamping member 118 in the upper portion of the latter. The bell shaped clamping member embodies suitable openings 127 for free accommodation of the springs 125 as the valve member is moved between the fully closed position shown and the fully open position indicated in chain lines 128. The clamping member is also apertured as at 129 to provide a bore opening therein conforming to and in alignment with the bore 107 of the valve body 106.

The valve seat member is first placed into the valve body while locating the same on the locating pin 130. The valve member assembly including the springs, valve member, supporting arm therefor and bell shaped clamping member, is then brought into registry with the locating pin 130 and placed in clamping relationship with the valve seat member. Thereafter, the cover 116 is placed onto the bonnet 113 over the assembly described and the bolts 117 tightened to firmly clamp the cover onto the bonnet. The valve assembly clamping screw 131 is then tightened to force the bell shaped clamping member into clamping engagement with the valve seat member to press the same into firm engagement with the recess 111 accommodating the valve seat tube. Locking nuts 132 are then fixed and a cover cap 133 screwed in place.

Aside from constructional differences, the form of the invention shown in Figures 8 and 9 is of slightly modified function as compared with the forms shown in the previous Figures. Thus, the spaced apart spring engaging lugs 134 extending from the outer face of the valve member 122 are adapted to engage the springs 125 as the valve member approaches its fully outward or open position. As before, the effective spring angle is reduced as the valve is opened until a point is reached at which engagement of the springs by the lugs 134 causes an effectively increasing spring angle. Therefore, the biasing force applied to the valve member decreases as the valve opens to a predetermined small value which is never negative at which the lugs 134 engage the springs 125 to increase the effective biasing force as the valve member is moved further outwardly. The valve member in its fully open position is therefore cushioned against its own inertia of motion during a fast opening of the valve as the valve member arrives at the fully open position.

It will be appreciated that the valve constructions herein disclosed, by virtue of the decrease in biasing force applied to the valve member as the valve is opened, enable the valve to be maintained in the open position under relatively light pressure of fluid flow. Yet, as the flow pressure decreases, the increasing biasing force applied to the valve member as it lowers under valve closing action, enables a fast closing of the valve. This characteristic is illustrated in Figure 10 wherein the pressures in a line containing a check valve of the invention are represented by the line 135. The sensitivity of the valve is indicated upon opening of the valve in less than 0.1 seconds under a pressure of less than five pounds per square inch as represented at the point X. Flow may continue without reversal up to a pressure of say twelve pounds per square inch as represented at Y. A small pressure reversal will occasion a quick closing of the valve as at Z followed by oscillation of the fluid column to a negative pressure peak value as at 136 followed by a positive pressure peak 137. Because the valve is closed before the pressure drops to zero, the positive pressure peak following valve closure is substantially limited to the maximum pressure previous to valve closing as will be apparent by examining the pressure represented at the point 137 as compared with the pressure at point Y. While the specific geometry of a check valve of the invention can have some influence upon the magnitude of the first positive pressure peak, there is a definite

indication from comparative tests with other check valves that the check valve of the invention overcomes the problem of high positive pressure peaks which are substantially in excess of pressure before closing, experienced with valves of the prior art. That this is attributable to the fast closing of the valve by reason of the application of biasing force to the valve member by way of the construction and method set forth herein, appears evident from the series of tests carried out, particularly having regard to the high natural response characteristics of the valve mechanism which may be accomplished by utilizing spring biasing means as set forth, whereby a higher period of resonance for the valve components is realized than heretofore.

From the foregoing, it will be apparent that the invention concerns a valve structure embodying an inclined valve seat member in a through-bore valve body wherein the bore is unobstructed by the valve mechanism and valve seat when the valve is fully open. Preferably, the inclination of the valve seat relative to the axis of the through-bore of the body should be about fifty degrees. A number of advantages accrue from a selection of a valve seat angle of about fifty degrees; in particular, substantially a maximum peripheral annulus of flow is provided upon opening of the valve through which the fluid carried thereby can flow. Also, an angle of about fifty degrees for the valve seat permits a much smaller angle of motion for the valve member from the fully open to the fully closed position than in valves of the prior art. Accordingly, during conditions of high rates of flow, the valve member opening is accomplished through a smaller angle of movement than if the valve seat were of circular or nearly circular cross-section. This characteristic, in conjunction with the action of the valve member biasing means as set forth, enables a quick closing of the valve to be accomplished before the pressure drops to zero.

Not only is the natural period of oscillation of the valve member made relatively high by the use of spring means as set forth but the component parts utilized in such construction are assembled in such manner that they are all removable through the bonnet opening without the valve having to be removed from the pipe line in which it is connected. Moreover, the bonnet conceals and protects the valve structure which it entirely encloses in the valve body.

While there has been described what is at present considered a preferred embodiment of the present invention, it will be appreciated by those skilled in the art that various changes and modifications can be made therein without departing from the invention and it is intended to cover herein all such changes and modifications as come within the scope of the appended claims.

WHAT WE CLAIM IS:

1. In a check valve having a valve body with a through-bore defining co-axially aligned valve inlet and outlet openings, a valve structure comprising: a valve seat member located in said bore between the inlet and outlet openings thereof and having seating surfaces defining a valve seat thereon inclined at an angle of the order of fifty degrees with respect to the axis of said bore; a valve member engageable with said valve seat to occlude reverse flow of fluid through said bore; a swingable valve supporting arm; means connecting one end of said arm to said valve member; fulcrum means supporting said arm for swinging motion of said valve member from a fully closed position of seating engagement with said valve seat to a fully open position beyond said bore; and means including a spring, biasing said arm withincreasing force toward the closed position as said valve member moves toward said valve seat for seating engagement therewith.

2. Valve structure as claimed in Claim 1 in which the swingable valve supporting arm moves through a relatively small angle from a fully closed position of seating engagement with said valve seat to a fully open position beyond the bore.

3. Valve structure as claimed in Claim 1 and a bonnet structure forming a part of the valve body and entirely enclosing the valve structure.

4. Valve structure as claimed in Claim 1 and a bonnet structure forming a part of said valve body and entirely enclosing the valve structure, said bonnet having a cavity adapted to accept said valve member therein when the latter is in the fully open position.

5. Valve structure as claimed in Claim 1 and a bonnet structure forming a part of said valve body entirely enclosing said valve structure and having a closable opening therein adapted to accommodate said valve structure.

6. Valve structure as claimed in Claim 1 and a bonnet structure forming a part of said valve body and entirely enclosing said valve structure therein; a cavity in said bonnet adapted to accommodate said valve member when the latter is in the fully open position, said bonnet structure having an opening adapted to pass said valve structure therethrough.

7. Valve structure as claimed in Claim 1 and means limiting the opening movement of said valve member away from said valve seat member to a position of clearance with respect to said through bore at which a minimum positive biasing pressure is applied to said valve member by said biasing means.

8. In a check valve having a valve body with a through-bore: a separable inclined valve seat disposed in the through-bore between the ends thereof; a bonnet forming a part of said valve body and having an open-

ing greater than the bore thereof located to accommodate said valve seat for removal of the latter therethrough; a valve member engageable with said valve seat for closure of the latter; a valve member supporting bias arm; means pivotally connecting one end of said bias arm to said valve member; fulcrum means pivotally supporting said bias arm for swingable action thereabout and motion of said valve member between the fully closed and fully open position with respect to said valve seat; spring means; means anchoring one end of said spring means; means connecting the other end of said spring means to said bias arm at a point thereon providing a decreasing effective angle for said spring as said bias arm and valve member are moved toward the fully open position of the valve; and means limiting the opening movement of said valve member to a position at which the said effective spring angle is substantially a minimum and is positive.

9. A check valve as claimed in Claim 8 and means for adjusting said valve member with respect to the valve member supporting bias arm.

10. A check valve as claimed in Claim 8 including means for anchoring the fulcrum means on the valve seat; and means limiting the opening movement of the valve member to a position at which the effective spring angle is substantially a minimum and is positive.

11. A check valve as claimed in Claim 8 having means limiting the opening movement of the valve member to a position at which the effective spring angle is substantially a minimum and is positive; and means for adjusting the valve member with respect to the supporting bias arm therefor.

12. A check valve as claimed in Claim 8 in which the spring means is in the form of a bow spring having one end anchored and the other end connected effectively to the valve member supporting bias arm at the point thereon providing a decreasing effective angle for the spring as the bias arm and valve member are moved toward the fully open position of the valve.

13. A check valve as claimed in Claim 8 in which the spring is in the form of a cantilever leaf spring.

14. A check valve as claimed in Claim 8 and a clamping member rising from the valve seat toward the bonnet opening and removable through the latter; means connecting the fulcrum means for the bias arm to the clamping member; a cover for the bonnet; and means in the cover for forcing the clamping member into firm engagement with the valve seat.

15. A check valve as claimed in Claim 8 and a piston element on the valve member projectable into the valve seat to reduce fluid flow between the valve seat and valve member during disengagement thereof.

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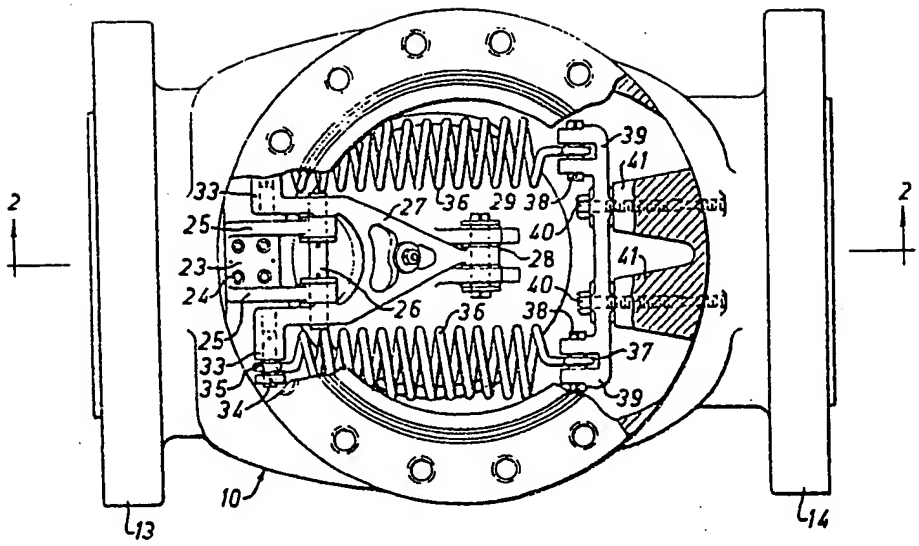
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FIG.1

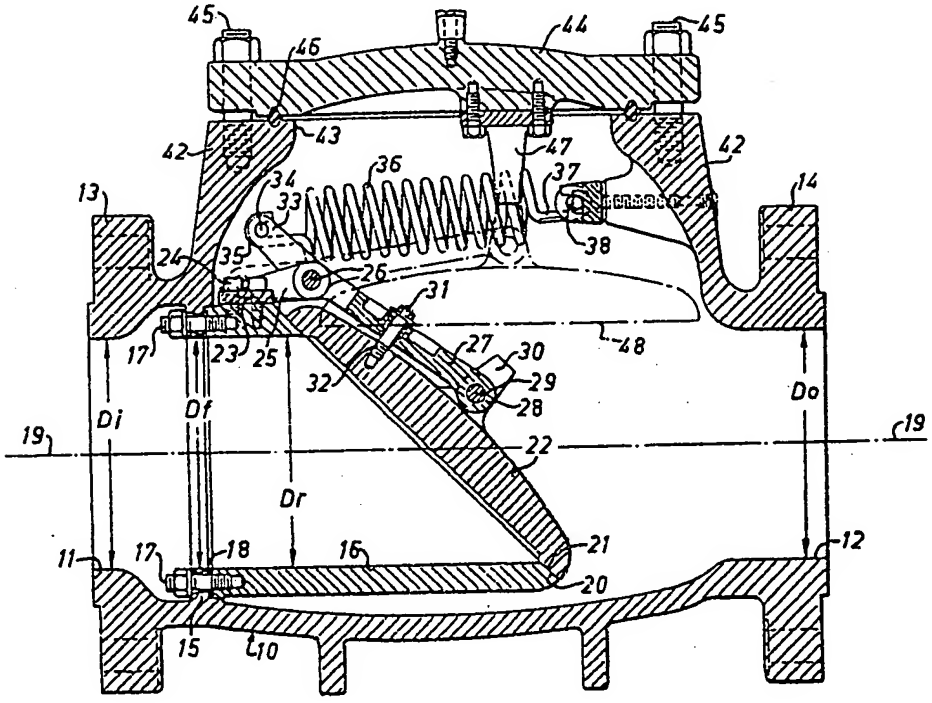
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FIG.2

811,237 COMPLETE SPECIFICATION

4 SHEETS

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SHEETS 1 & 2

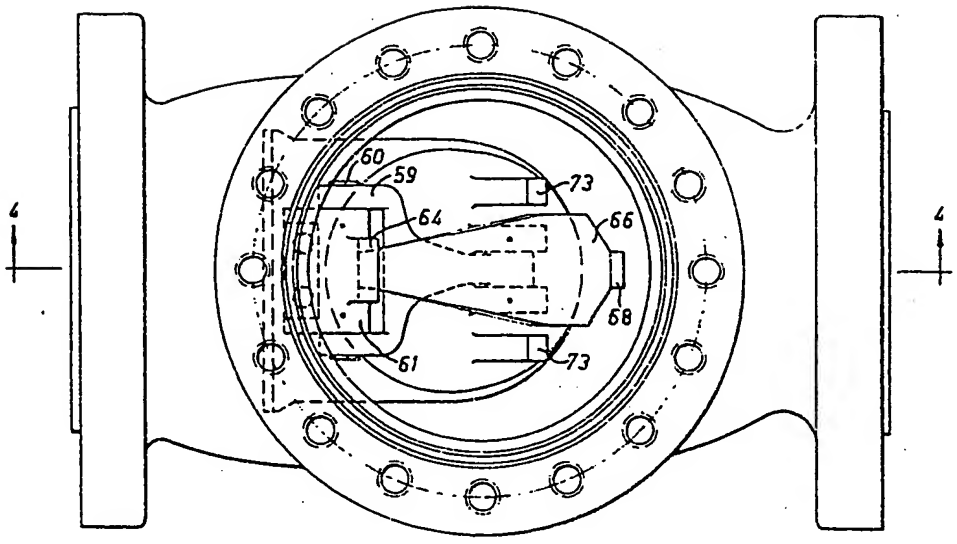

FIG. 3

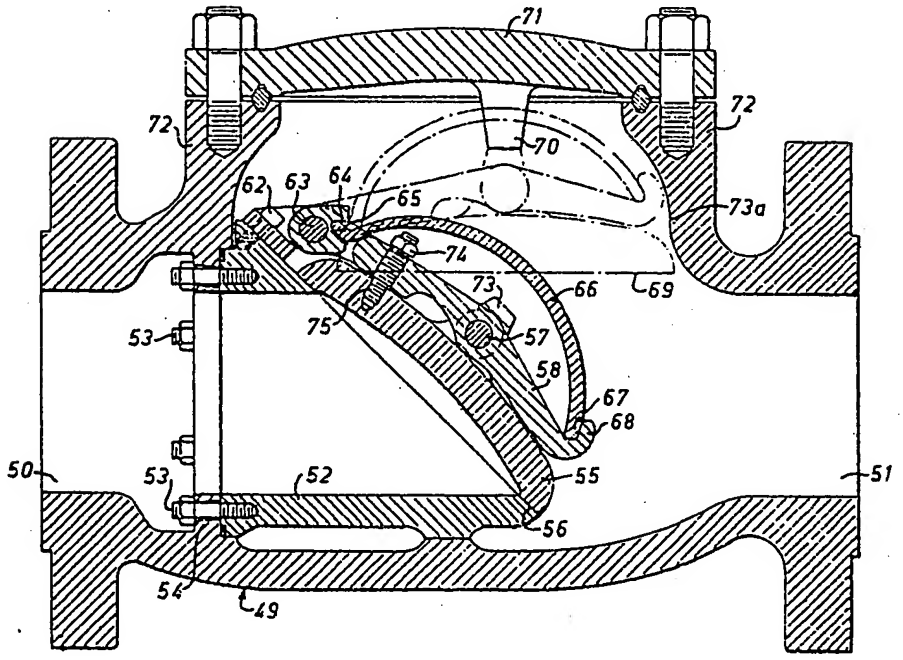

FIG. 4

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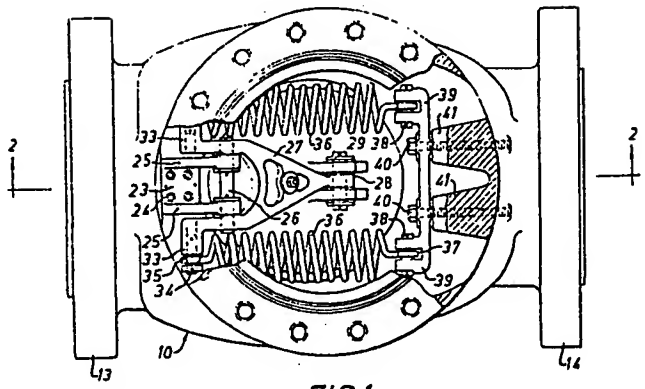


FIG. 1

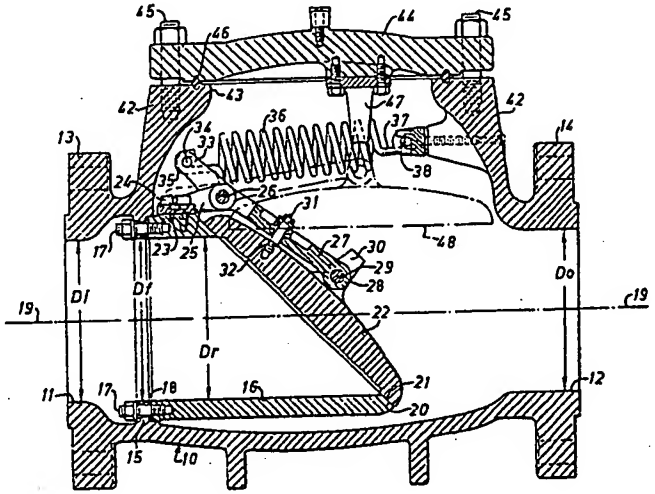


FIG. 2

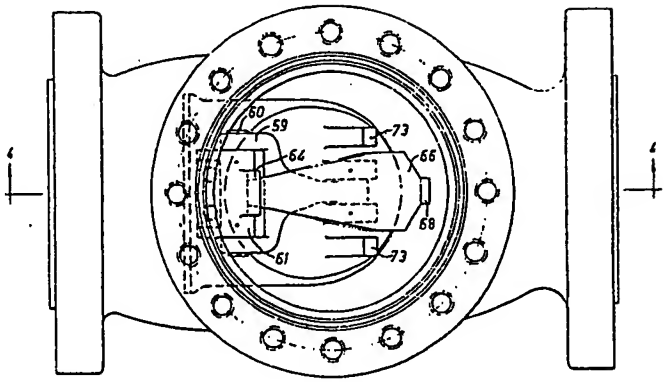


FIG. 3

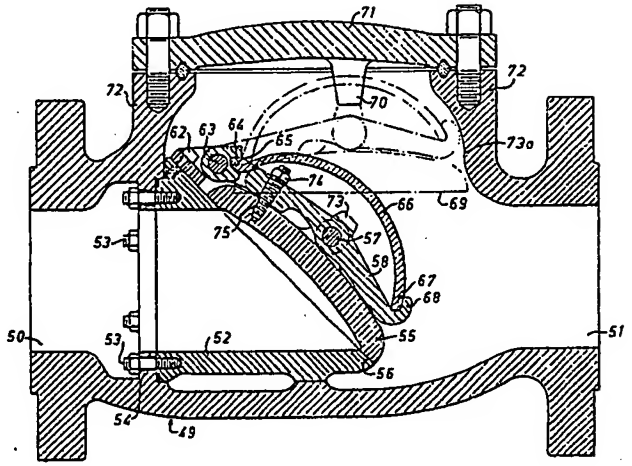


FIG. 4

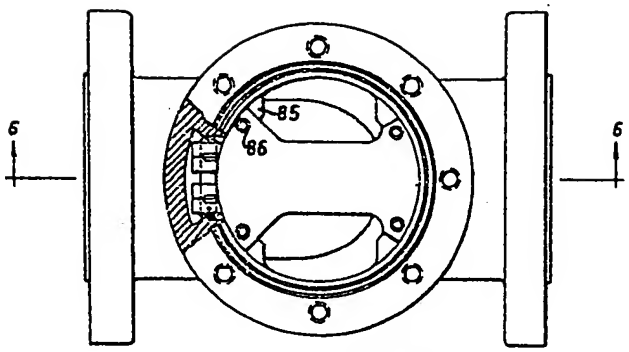


FIG. 5

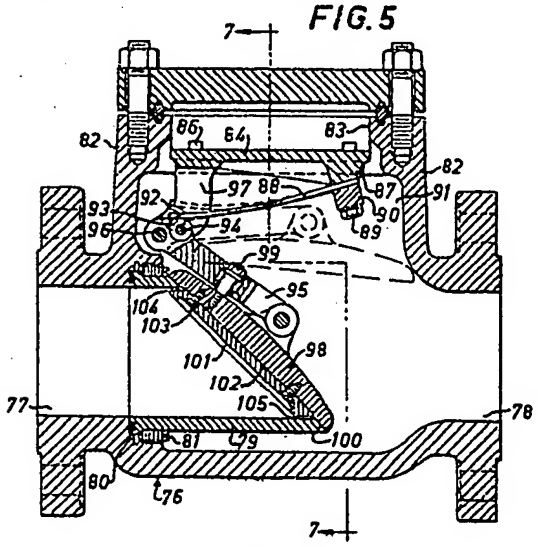


FIG. 6

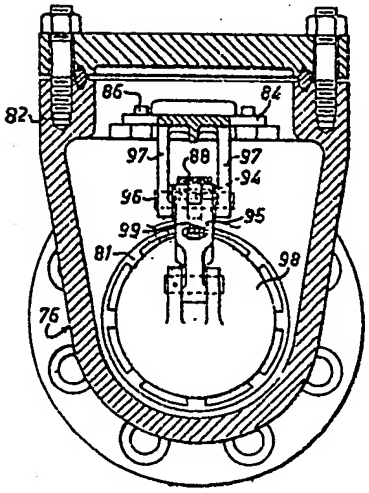


FIG. 7

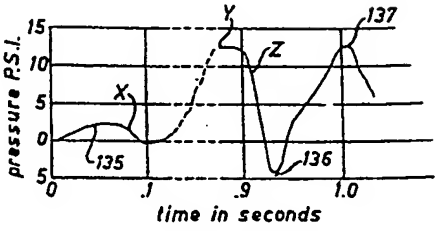
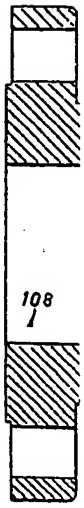


FIG. 10



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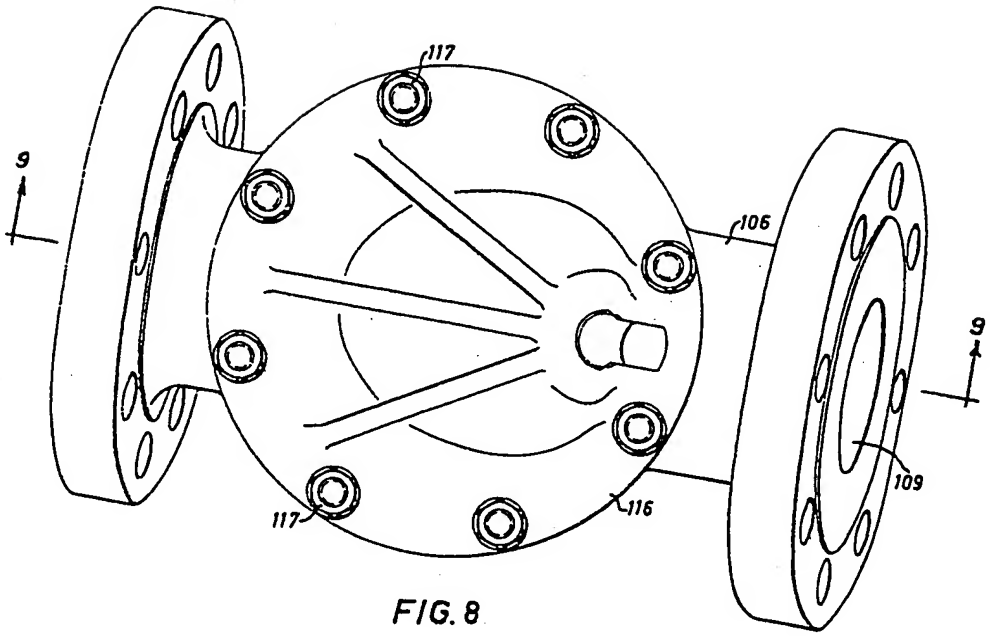

FIG. 8

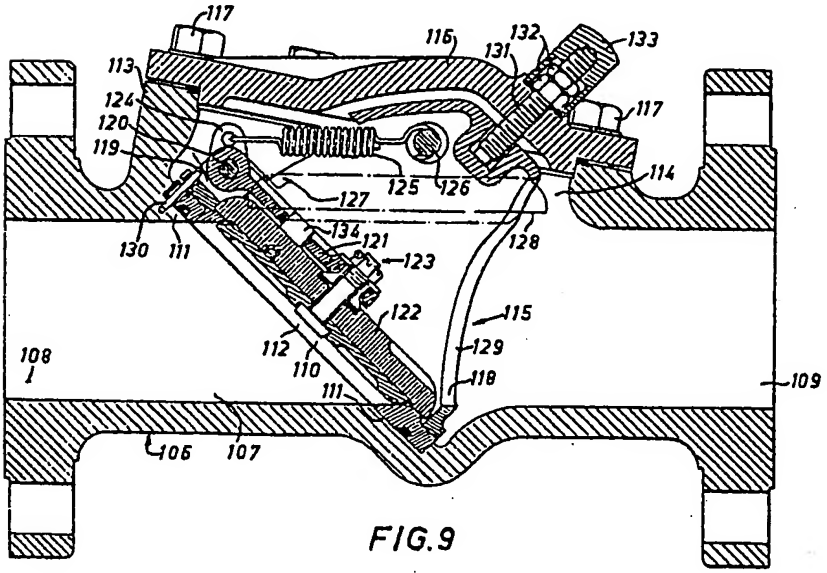

FIG. 9

811,237 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 3 & 4

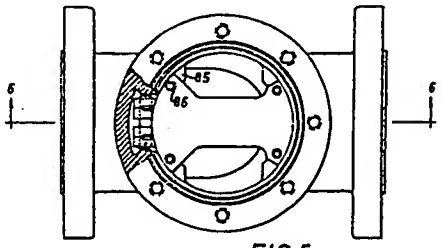

FIG. 5

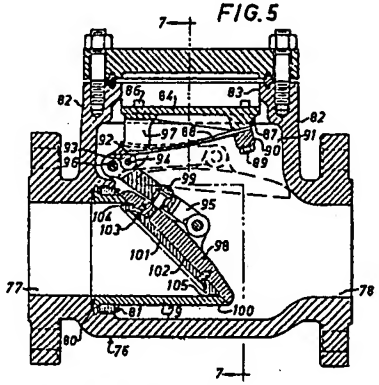

FIG. 6

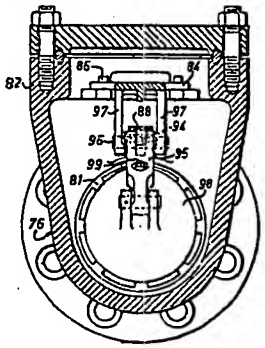

FIG. 7

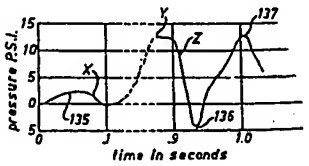

FIG. 10

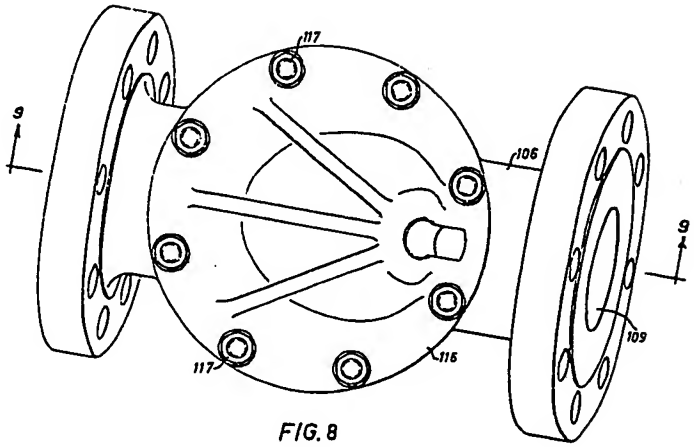

FIG. 8

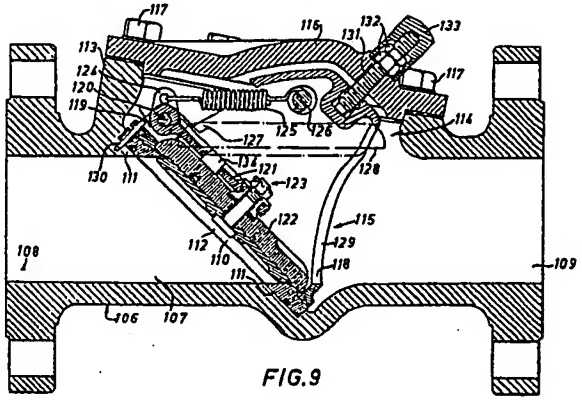

FIG. 9